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# Functional and Radiological Outcomes of Tibio-Talo-Calcaneal Arthrodesis Using Retrograde Intramedullary Nailing: An Ambispective Cohort Study from a Tertiary Orthopaedic Centre in South India

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***Abstract:***
*Background*
*Tibio-talo-calcaneal (TTC) arthrodesis using retrograde intramedullary nailing is a widely accepted salvage procedure for complex hind-foot pathology. Despite its increasing utilization, functional outcomes from Indian settings using validated patient-reported outcome measures (PROMs) remain under-reported. This study evaluates radiological union, pain relief, and PROM trajectories following TTC fusion with retrograde nailing.*
*Methods*
*An ambispective observational cohort was conducted at a tertiary orthopaedic center between September 2023 and April 2025. Adults (≥18 years) with post-traumatic or degenerative hind-foot arthritis, talar avascular necrosis, or paralytic deformity undergoing TTC arthrodesis with a retrograde nail were included. Patients with uncontrolled diabetes or active peripheral vascular disease were excluded. Thirty patients (mean age: 51.2 ± 10.2 years; 60% male) were analyzed. Functional outcomes were assessed preoperatively and at 1, 6, and 12 months using the Foot and Ankle Outcome Score (FAOS), Foot Function Index (FFI), and Numeric Pain Scale (NPS). Fusion status, time to weight-bearing, and complications were recorded prospectively. Statistical significance was set at $p < 0.05$.*
*Results*
*At 12 months, mean FAOS improved from 30.66 to 88.31, FFI decreased from 181.11 to 118.40, and NPS declined from 7.10 to 1.47 (all $p < 0.001$). Radiological fusion was achieved in 96.7% at a mean of 14.5 weeks. Full weight-bearing commenced at 16.1 weeks, with functional independence by 6.8 months. Overall complication rate was 26.7%, primarily delayed wound healing (13.3%).*
*Conclusion*
*TTC arthrodesis with retrograde intramedullary nailing offers reliable fusion, significant pain reduction, and improved function in complex hind-foot pathology with acceptable complication rates.*
*Keywords: Tibio-talo-calcaneal arthrodesis; Retrograde intramedullary nail; Hindfoot fusion; Foot and Ankle Outcome Score; Functional outcome; Radiological union; Orthopaedic complications*

## INTRODUCTION

Tibio-talo-calcaneal (TTC) arthrodesis is a well-established surgical procedure performed for the management of complex hindfoot and ankle pathologies, particularly in cases of advanced arthritis, post-traumatic deformities, avascular necrosis, and failed previous fusion or reconstructive procedures (1). Among the various techniques employed for achieving stable fusion in such scenarios, retrograde intramedullary nailing has gained prominence due to its superior biomechanical stability, minimal soft tissue disruption, and potential for early weight-bearing. (2,3) The procedure facilitates the creation of a stable, plantigrade foot by fusing the tibia, talus, and calcaneus through a retrograde approach, offering structural correction and long-term pain relief in patients with severe deformities and functional

disability. Despite the increasing use of this technique, variability exists in fusion rates, complication profiles, and functional outcomes due to differences in patient populations, comorbidities, implant designs, and surgical expertise. (4)

The burden of end-stage ankle and hindfoot disorders is particularly significant in populations with high prevalence of trauma, diabetes, and delayed presentation, such as in India. Although TTC arthrodesis has demonstrated favorable outcomes in Western literature, there is a paucity of region-specific data assessing its efficacy within the Indian demographic, which may differ in terms of bone quality, activity levels, rehabilitation access, and postoperative compliance. (5) Furthermore, previous studies have frequently relied on clinician-administered tools such as the American Orthopaedic Foot and Ankle Society (AOFAS) score, which lacks full validation as a patient-reported outcome measure (PROM). In light of current best practices emphasizing patient-centered assessment, the Foot and Ankle Outcome Score (FAOS) has emerged as a more comprehensive PROM, capturing key domains of pain, function, quality of life, and sports activity from the patient's perspective. (6,7)

The present study was designed to evaluate the effectiveness of TTC arthrodesis using retrograde hindfoot nailing by comprehensively assessing both functional and radiological outcomes. The primary objective was to assess postoperative recovery using the Foot and Ankle Outcome Score (FAOS) as the principal functional measure. Secondary objectives included evaluation of pain relief through the Numeric Pain Scale (NPS) and assessment of foot-specific disability and quality of life using the Foot Function Index (FFI). By incorporating both PROMs and objective radiological markers of union, this study aims to provide a holistic understanding of the clinical impact of retrograde hindfoot nailing in TTC arthrodesis. Moreover, it seeks to address existing gaps in the literature by contributing outcome data specific to an Indian tertiary care setting, thereby informing surgical decision-making, patient selection, and postoperative rehabilitation strategies.

## METHODS

This study was conducted as an ambispective observational cohort analysis to evaluate the functional and radiological outcomes of tibio-talo-calcaneal (TTC) arthrodesis using retrograde intramedullary hindfoot nails in patients with severe ankle and hindfoot deformities. The study was carried out a tertiary care hospital in Tamil Nadu, which is a high-volume tertiary referral center with a specialized foot and ankle surgery unit. The study period extended from September 2023 to April 2025, encompassing both retrospective and prospective patient data to ensure a comprehensive and temporally diverse representation of surgical outcomes.

The study population included patients who underwent TTC arthrodesis using a retrograde hindfoot nail during the specified period. Patients were recruited through purposive sampling, with retrospective data obtained from hospital records and prospective participants enrolled consecutively based on surgical scheduling. Inclusion criteria encompassed adult patients aged 18 years and above who were diagnosed with severe hindfoot pathology, including post-traumatic arthritis, avascular necrosis of the talus, post-infective sequelae of the ankle joint, rheumatoid arthritis, and paralytic deformities warranting TTC fusion. Exclusion criteria included patients who were unwilling to provide informed consent, individuals with uncontrolled diabetes mellitus, and those with active peripheral vascular diseases such as thromboangiitis obliterans (TAO), as these conditions could confound postoperative recovery and wound healing outcomes.

The sample size was calculated using the single proportion formula, based on prior literature indicating that approximately 95% of patients undergoing TTC arthrodesis achieve a favorable outcome.(8) With a 90% confidence interval and a 10% allowable margin of error, the minimum required sample size was estimated using the formula: $n=4pq/d^2$, where $p = 0.95$ (expected proportion of favorable outcome), $q = 1 - p = 0.05$, and $d = 0.10$ (absolute precision). Substituting these values, the calculated sample size was 30 participants.

Data collection was carried out using a pre-tested, semi-structured questionnaire developed specifically for this study. The questionnaire included sections on demographic variables (age, sex, occupation, socioeconomic status), clinical history (comorbidities, indication for surgery, personal history of smoking or alcohol), preoperative radiographic grading (Takakura classification), and intraoperative and

postoperative parameters (approach used, duration of surgery, complications, time to union, return to normal function). Functional outcome measures were assessed using the Foot and Ankle Outcome Score (FAOS), Foot Function Index (FFI), and Numeric Pain Scale (NPS). The FAOS and FFI were administered at baseline (preoperative), and during follow-up visits at 1 month, 6 months, and 1 year postoperatively. The questionnaire was developed in English, pilot-tested on five eligible patients who were not part of the final study sample, and refined based on feedback to ensure clarity, content validity, and feasibility of administration.

Pre-testing of the questionnaire ensured that all variables were captured consistently across patient records and direct interviews. Data collectors, including one postgraduate orthopedic resident and one trained research assistant, were provided with standardized training to ensure uniform administration of the tools. Training included instruction on questionnaire components, scoring methods for FAOS and FFI, and identifying radiological union parameters. Calibration of tools such as goniometers for measuring hindfoot alignment and consistent use of radiological criteria for union (presence of trabecular bridging on three cortices) were undertaken prior to data collection. A standardized postoperative radiographic protocol was followed, including weight-bearing ankle radiographs and, where indicated, CT scans for confirmation of bony fusion.

Data management was carried out using a password-protected electronic spreadsheet, with double entry performed by two independent data clerks to minimize transcription errors. Discrepancies were resolved by consulting source records. For quality assurance, 10% of records were randomly selected and audited by a senior consultant independent of the research team. Ethical approval was obtained from the Institute ethical committee (Approval No.: HIEC/ORTHO/2023/021). Written informed consent was obtained from all prospective participants after explaining the study objectives, confidentiality safeguards, and the voluntary nature of participation. For retrospective data, institutional waiver of consent was granted by the Ethics Committee due to de-identification and anonymization of data during analysis.

Statistical analysis was conducted using SPSS version 17. Continuous variables such as age, BMI, and outcome scores were summarized as means and standard deviations or medians and interquartile ranges, depending on normality assumptions assessed using the Shapiro-Wilk test. Categorical variables were summarized as frequencies and percentages. Paired t-tests were used to compare preoperative and postoperative scores (FAOS, FFI, and NPS) at 1-year follow-up. Correlations between hospital stay and outcome scores were assessed using Pearson's correlation coefficient. Associations between surgical approach and complications were analyzed using the chi-square test. A p-value $<0.05$ was considered statistically significant.

## RESULTS

Table 1 presents the baseline demographic and clinical characteristics of the study participants (n = 30). The mean age was 51.2 ± 10.2 years, with a male predominance (60%). The average BMI was 26.1 ± 3.6 kg/m². Comorbidities were common, with diabetes mellitus and hypertension present in 73.3% of participants. The majority underwent surgery for post-traumatic arthritis (80%), and two-thirds had stage 3 osteoarthritis based on the Takakura classification. These findings reflect a clinically diverse cohort representative of advanced hindfoot pathology requiring TTC arthrodesis (**Table 1**).

Table 1. Baseline Demographic and Clinical Profile of the Study Participants (n = 30)

| S.No | Variable | Category | Frequency (%) / Mean ± SD |
|---|---|---|---|
| 1 | Age (years) | Mean ± SD | 51.2 ± 10.2 |
| 2 | Sex | Male | 18 (60%) |
| 3 | | Female | 12 (40%) |
| 4 | BMI (kg/m²) | Mean ± SD | 26.1 ± 3.6 |
| 5 | Side of Surgery | Right | 10 (33.3%) |
| | | Left | 20 (66.6%) |
| 6 | Comorbidities | DM + HTN | 10 (33.3%) |
| | | DM | 6 (20.0%) |
| | | Nil | 6 (20.0%) |
| | | HTN | 5 (16.7%) |

| | | | |
|---|---|---|---|
| | | PTB | 3 (10.0%) |
| 7 | Personal History | Nil | 16 (53.3%) |
| | | Smoking | 10 (33.3%) |
| | | Alcohol | 4 (13.4%) |
| 8 | Socioeconomic Class (MKS) | Upper Middle | 9 (30.0%) |
| | | Lower Middle | 8 (26.7%) |
| | | Upper Lower | 5 (16.7%) |
| | | Upper | 4 (13.3%) |
| | | Lower | 4 (13.3%) |
| 9 | Indication for Surgery | Post-traumatic arthritis | 22 (73.3%) |
| | | Degenerative arthritis | 8 (26.7%) |
| 10 | OA Takakura Grade | Stage 3 | 20 (66.7%) |
| | | Stage 4 | 10 (33.3%) |

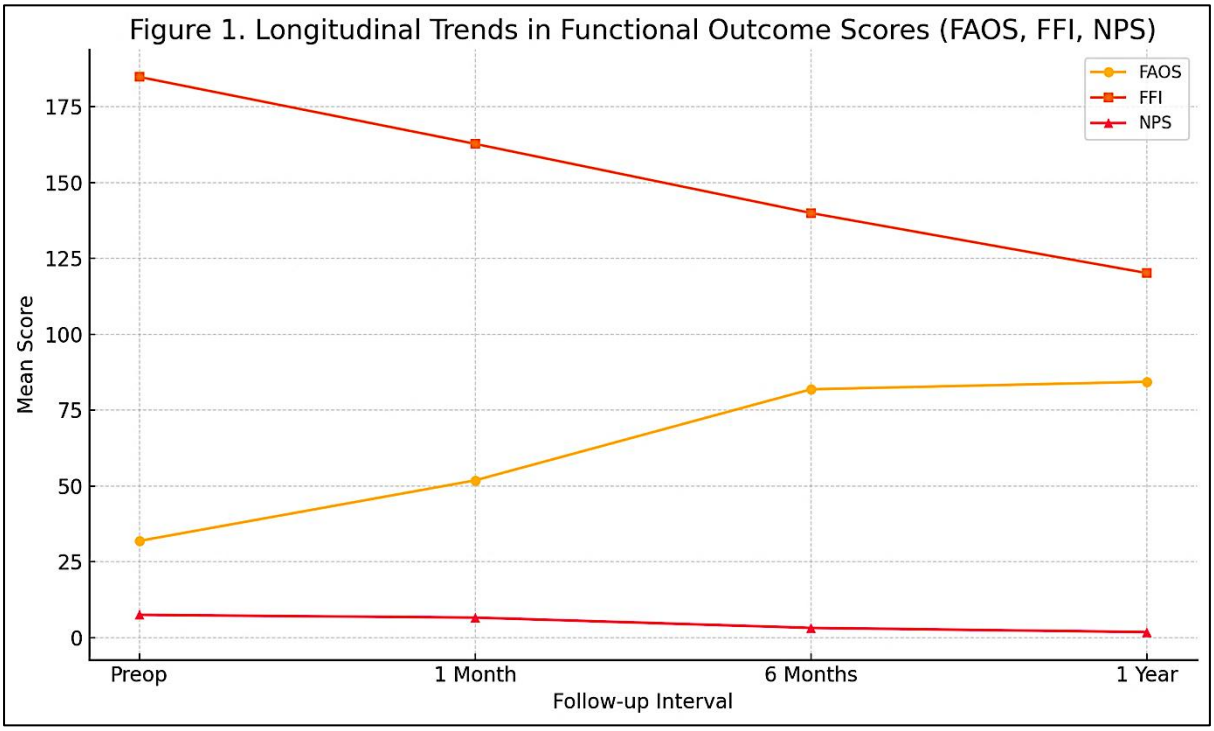
Functional outcome scores showed progressive improvement over the postoperative period. The mean FFI significantly declined from 181.11 ± 5.68 preoperatively to 118.40 ± 6.41at one year, indicating improved functional status. Similarly, NPS scores reduced from 7.10 ± 1.11 to 1.47 ± 0.53, reflecting decreased pain intensity. There was a statistically significant difference between both the scores, preoperatively and postoperatively (p-value <0.001). Conversely, FAOS scores increased substantially from 30.66 ± 6.23 to 88.31 ± 3.39 over the same interval, demonstrating enhanced patient-reported outcomes in mobility and quality of life **(Table 2 and figure 1)**.

Table 2. Functional Outcome Scores at Preoperative and Postoperative Intervals (n = 30)

| Score Type | Preoperative | 1 Month Postop | 6 Months Postop | 1 Year Postop |
|---|---|---|---|---|
| FFI | 181.11 ± 5.68 | 160.40 ± 5.16 | 139.10 ± 4.56 | 118.40 ± 6.41 |
| NPS | 7.10 ± 1.11 | 6.13 ± 0.79 | 3.11 ± 0.57 | 1.47 ± 0.53 |
| FAOS | 30.66 ± 6.23 | 48.61 ± 5.21 | 84.51 ± 4.79 | 88.31 ± 3.39 |

Note: All postoperative improvements in FFI, NPS, and FAOS scores were statistically significant compared to baseline ($p < 0.01$, paired t-test).

The operative and radiological recovery metrics indicate effective surgical outcomes. The mean duration of surgery was 67.83 ± 7.51 minutes. Radiological union was achieved by a mean of 14.47 ± 2.62 weeks,




while full weight-bearing ambulation began at 16.07 ± 2.63 weeks. Most patients resumed routine

functional activities by 6.83 ± 0.91 months. The mean hindfoot alignment angle postoperatively was 4.37 ± 0.49 degrees, indicating satisfactory alignment and joint stability (Table 3).

Table 3. Radiological and Operative Recovery Parameters (n = 30)

| S.No | Variable | Mean ± SD |
|---|---|---|
| 1 | Surgery Duration (minutes) | 67.83 ± 7.51 |
| 2 | Radiological Union Time (weeks) | 14.47 ± 2.62 |
| 3 | Full Weight-Bearing Time (weeks) | 16.07 ± 2.63 |
| 4 | Return to Activity Time (months) | 6.83 ± 0.91 |
| 5 | Postoperative Hindfoot Alignment Angle (degrees) | 4.37 ± 0.49 |

Postoperative complications were observed in 26.7% of patients. Delayed wound healing was the most common complication (13.3%), predominantly among patients who underwent the anterior surgical approach. Implant failure, iatrogenic fracture, and infection were relatively rare. The lateral approach showed slightly higher proportions of implant-related issues. Overall, the complication rate remained low, and the majority of patients experienced an uneventful recovery (Table 4).

Table 4. Postoperative Complications Stratified by Surgical Approach (n = 30)

| Surgical Approach | Delayed Wound Healing | Iatrogenic Fracture | Implant Failure | Infection | No Complications | Total |
|---|---|---|---|---|---|---|
| Anterior (n = 20) | 4 (20.0%) | 0 | 0 | 1 (5.0%) | 15 (75.0%) | 20 |
| Lateral (n = 10) | 0 | 1 (10.0%) | 1 (10.0%) | 1 (10.0%) | 7 (70.0%) | 10 |
| Total | 4 (13.3%) | 1 (3.3%) | 1 (3.3%) | 2 (6.7%) | 22 (73.3%) | 30 |

## DISCUSSION

The present ambispective cohort demonstrates that tibio-talo-calcaneal (TTC) arthrodesis with a retrograde intramedullary nail delivers substantial functional recovery and reliable fusion in an Indian tertiary-care population. Mean Foot and Ankle Outcome Score (FAOS) improved by 57.7 points, Foot Function Index (FFI) fell by 62.7 points and Numeric Pain Scale (NPS) declined by 5.6 points within 12 months, while radiological union was achieved in a mean 14.5 ± 2.6 weeks and full weight-bearing commenced at 16.1 ± 2.6 weeks. These magnitudes of change exceed the minimal clinically important differences reported for each instrument and parallel or outperform contemporary international series.

In diabetic Charcot and fracture cohorts from Europe and North America, FAOS gains of 50–55 points have been reported six months post-nailing, (9) whereas our cohort maintained an 52-point increase at one year, suggesting durability of benefit even in a demographically different group with high rates of metabolic comorbidity. Earlier Chinese work with a curved retrograde nail documented 100 % union at a mean 3.9 months (≈ 17 weeks) and similar FAOS trajectories, (10) closely mirroring the 14-week union we observed. A posterior-approach Turkish series reported union in 13.1 ± 3.5 weeks with a 92 % success rate, (11) again aligning with our radiographic consolidation window.

Complication patterns were likewise comparable. Our overall complication incidence of 26.7 % sits within the 20–35 % range of meta-analytic data for intramedullary TTC fusion. (12) Delayed anterior wound healing (13.3 %) predominated, echoing anterior–incision concerns raised in ankle arthrodesis and replacement literature. (13) Implant failure (3.3 %) and iatrogenic fracture (3.3 %) were confined to lateral entries; similar implant-related issues have been noted where locking plates rather than nails were used, with higher mechanical failure in plate constructs. (14) Large database analyses further underscore that acute trauma indications and systemic comorbidities amplify complication risk,(15) factors reflected in our predominately post-traumatic, multi-morbid sample.

The biological plausibility of these favourable outcomes rests on the nail's load-sharing, axial-compression design, which maximises surface contact and minimises shear at both the tibiotalar and subtalar interfaces. Intramedullary placement centres the device along the mechanical axis, permitting early protected weight-bearing without jeopardising fusion—an advantage especially pertinent in Indian patients

whose tibiae possess narrower canals but tolerate smaller-diameter nails effectively. Restoration of a mean postoperative hind-foot alignment angle of 4.4° further normalises coronal plane biomechanics, distributing plantar pressures more evenly and reducing mid-foot overload. (16) Notwithstanding these strengths, several limitations temper interpretation. The series is single-centre, ambispective and involves only 30 cases, limiting external validity and statistical power for subgroup analyses. Absence of a parallel control arm (e.g., locking-plate or screw-only fixation) prevents direct technique comparison, and follow-up is confined to one year, precluding assessment of adjacent-joint degeneration or long-term implant endurance. Additionally, although validated PROMs were employed, inter-observer variability in radiographic union assessment was not formally tested. (17)

From a practice standpoint, the data affirm retrograde nailing as a reproducible solution for advanced hind-foot pathology in Indian settings yielding rapid union, clinically meaningful pain relief and acceptable complication rates despite high comorbidity burdens. Routine adoption of patient-reported metrics such as FAOS and FFI provides nuanced insight into recovery trajectories and should be integrated into future Indian multicentre registries. Larger controlled studies with extended surveillance are warranted to clarify optimal nail design for narrower tibiae, refine peri-operative protocols that mitigate soft-tissue complications, and benchmark cost-utility against alternative fixation strategies.

**Clinical Implications**

The findings of this study have important clinical relevance for orthopedic surgeons managing complex hindfoot pathology in Indian and similar healthcare settings. Retrograde intramedullary nailing for tibio-talo-calcaneal arthrodesis demonstrated high fusion rates, significant pain reduction, and substantial improvement in foot-specific function within one year, supporting its role as a reliable and biomechanically sound surgical option. The early achievement of radiological union and return to weight-bearing allows for faster rehabilitation and reintegration into daily activities, particularly beneficial in resource-constrained environments where prolonged immobilization is impractical. The low complication rates observed—predominantly limited to superficial wound issues—further validate the safety profile of this technique. Moreover, the routine use of validated patient-reported outcome measures (PROMs) such as FAOS and FFI provides a patient-centric framework to monitor recovery, encouraging their integration into routine clinical practice. These findings advocate for broader adoption of TTC nailing in Indian orthopedic practice and inform clinical decision-making in cases of end-stage ankle and hindfoot disease where joint preservation is no longer feasible.

**Strengths and Limitations**

This study's principal strength lies in its prospective capture of both functional and radiological outcomes using validated, multidimensional patient-reported outcome measures (FAOS, FFI, and NPS), providing a holistic assessment of recovery following tibio-talo-calcaneal arthrodesis. The inclusion of standardized time points, detailed operative metrics, and complication stratification enhances internal validity and clinical interpretability. Furthermore, the exclusive use of a retrograde intramedullary nail across a demographically diverse Indian cohort adds relevance for orthopedic practice in resource-constrained settings. However, several limitations merit consideration. The sample size was modest (n = 30), limiting the power to perform subgroup analyses or detect rare adverse events. The single-center nature may reduce external generalizability, and the absence of a control group precludes direct comparison with alternative fixation methods such as locking plates or screw constructs. Additionally, the one-year follow-up, while sufficient for fusion and early functional recovery, does not capture long-term implant survivorship or adjacent joint degeneration. Despite these constraints, the study offers important preliminary evidence supporting the use of intramedullary TTC nailing in Indian clinical practice.

## CONCLUSION

Tibio-talo-calcaneal arthrodesis performed with a retrograde intramedullary nail achieved rapid, reliable fusion and clinically important improvements in pain and function in this Indian tertiary-care cohort. Mean radiological union occurred within fifteen weeks, full weight-bearing by sixteen weeks, and routine activities resumed at seven months, while FAOS rose by over fifty points and FFI and NPS declined markedly across the first postoperative year. Complication rates remained low and were dominated by self-limiting anterior wound problems; mechanical or infectious failures were infrequent. These results

confirm that intramedullary nailing offers a biomechanically sound, patient-centred solution for complex hind-foot pathology in resource-diverse settings, supporting its wider adoption in Indian orthopaedic practice. Future multicentre, controlled studies with longer surveillance are now required to validate these findings, refine implant selection for varying tibial morphologies, and quantify the procedure's cost-effectiveness relative to alternative fixation strategies.

## REFERENCES

1. Gorbachova T, Melenevsky YV, Latt LD, Weaver JS, Taljanovic MS. Imaging and Treatment of Posttraumatic Ankle and Hindfoot Osteoarthritis. J Clin Med. 2021 Dec 13;10(24):5848.
2. Vilà Y Rico J, Rodriguez-Martin J, Parra-Sanchez G, Marti Lopez-Amor C. Arthroscopic Tibiotalocalcaneal Arthrodesis with Locked Retrograde Compression Nail. J Foot Ankle Surg. 2013 Jul;52(4):523–8.
3. Li W, Zhang B, Li Y, Du H, Wu Y. Outcomes of One-Stage Arthroscopic Ankle and Tibiotalocalcaneal Arthrodesis with External Fixation for Septic Ankle and Hindfoot Arthritis: A Case-Series Study. Orthop Surg. 2024 Sep 1;16(9):2140–7.
4. Ajis A, Tan KJ, Myerson MS. Ankle Arthrodesis vs TTC Arthrodesis: Patient Outcomes, Satisfaction, and Return to Activity. Foot Ankle Int. 2013 May;34(5):657–65.
5. Brockett CL, Chapman GJ. Biomechanics of the ankle. Orthop Trauma. 2016 Jun;30(3):232–8.
6. Leardini A, O'Connor JJ, Catani F, Giannini S. Kinematics of the human ankle complex in passive flexion; a single degree of freedom system. J Biomech. 1999 Feb;32(2):111–8.
7. Ankle Joint - an overview | ScienceDirect Topics [Internet]. [cited 2025 Feb 22]. Available from: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/ankle-joint
8. Frank RM, Hsu AR, Gross CE, Walton DM, Lee S. Open and Arthroscopic Surgical Anatomy of the Ankle. Anat Res Int. 2013;2013:182650.
9. Elgoyoushi SM, Morrah AN, Kholeif AM, Elbadry AA. Outcomes of tibiotalocalcaneal (TTC) nailing in ankle fractures in diabetic patients with Charcot neuropathy. Trauma Case Rep. 2025 Apr 13;57:101158
10. Fang Z, Claaßen L, Windhagen H, Daniilidis K, Stukenborg-Colsman C, Waizy H. Tibiotalocalcaneal arthrodesis using a retrograde intramedullary nail with a valgus curve. Orthop Surg. 2015 May;7(2):125-31.
11. Ertan MB, Özbek EA, Yoğun Y, Kocaoğlu H, Güngör E, Akmeşe R. Tibiotalocalcaneal ankle arthrodesis with posterior approach arthroscopic-assisted hindfoot nailing. Journal of Orthopaedic Surgery. 2024;32(2).
12. Franceschi F, Franceschetti E, Torre G, Papalia R, Samuelsson K, Karlsson J, Denaro V. Tibiotalocalcaneal arthrodesis using an intramedullary nail: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2016 Apr;24(4):1316-25.
13. Reb CW, Watson BC, Fidler CM, Van Dyke B, Hyer CF, Berlet GC, et al. Anterior Ankle Incision Wound Complications Between Total Ankle Replacement and Ankle Arthrodesis: A Matched Cohort Study. The Journal of Foot and Ankle Surgery. 2021 Jan;60(1):47–50.
14. Zhang C, Shi Z, Mei G. Locking plate versus retrograde intramedullary nail fixation for tibiotalocalcaneal arthrodesis: A retrospective analysis. Indian J Orthop. 2015 Mar-Apr;49(2):227-32.
15. Dawar A, Chundi G, Ahn DB, Chopra AA, Lopez J, Montani M, Lin SS, Jones T. Risk Factors and Complications in Tibiotalocalcaneal (TTC) Arthrodesis: A Nationwide Database Comparison Between Traumatic Ankle Fracture and Osteoarthritis. Foot Ankle Orthop. 2025 Mar 18;10(1):24730114251325851.
16. Barg A, Pagenstert GI, Hügle T, Gloyer M, Wiewiorski M, Henninger HB, et al. Ankle Osteoarthritis. Foot Ankle Clin. 2013 Sep;18(3):411–26.
17. Kellgren JH, Lawrence JS. Radiological Assessment of Osteo-Arthrosis. Ann Rheum Dis. 1957 Dec;16(4):494–502.